MONOCHROMATIC PHOTOGRAPHY OF JUPITER AND SATURN

By R. W. Wood

DEPARTMENT OF PHYSICS, JOHNS HOPKINS UNIVERSITY

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Photographs of the moon, which I made several years ago by means of ultra-violet light, revealed the existence of an extensive dark area surrounding the crater Aristarchus, which did not appear on plates made by means of yellow light, and could not be detected visually. Control experiments, made in the laboratory, made it appear probable that this deposit consisted of sulphur or sulphur bearing rock.

It appeared to me probable that even more interesting results would be obtained in the case of the planets, especially Mars, and preliminary experiments were carried on during the past summer at my East Hampton Laboratory with a horizontal telescope of 56 feet focal length and 16 inches aperture, figured by Mellish, and nickel plated by the method described in the *Astrophysical Journal* for October.

A deposit of nickel is necessary for the reason that silver reflects only 4% of the light in the region of the spectrum utilized, which lies between wave-lengths 3000 and 3300. This mirror was utilized in conjunction with a large Gaertner coelostat, which was placed at my disposal by the Naval Observatory. The mirror of this instrument was replaced by a 16-inch flat, also nickel plated, and photographs were made of the moon and Jupiter by means of infra-red, yellow, violet and ultra-violet light. Notwithstanding the fact that a moving plate holder, provided with eye-pieces for accurate following, was used, it was found difficult to secure sufficiently sharp definition, owing to the rather rapid periodic drift of the image which was very difficult to follow. The seeing moreover was not very good, and on the few nights when it was fair the mosquitoes were bad. Much valuable experience was gained however in the use of the monochromatic ray filters.

In the earlier experiments on the moon, I used, for the ultra-violet ray filter, a rather thick deposit of metallic silver on uviol glass. This was abandoned in the present work, owing to its great opacity even for the ultra-violet region transmitted, and a rectangular glass cell, closed with plates of uviol glass, and filled with dense bromine vapor, used in its place. Such a cell, when used with an ordinary (i.e., not isochromatic) plate, gives a photographic image formed by wave-lengths below 3500 exclusively. By combining it with a thin layer of a very dilute solution of chromate of potash, the transmission is practically

the same as with the silver film, while the time of exposure is only about one-tenth as long.

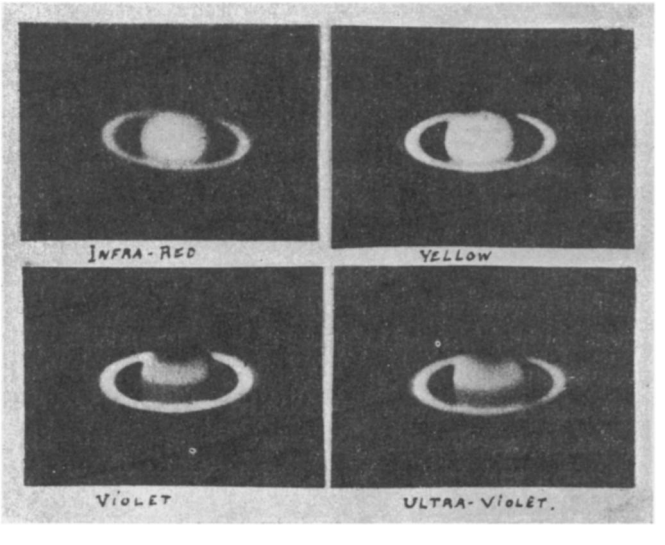
In October, through the courtesy of Dr. G. E. Hale, Director of the Mt. Wilson Observatory, the 60 inch reflector was placed at my disposal for four nights, and by working continuously from sunset to dawn, I was able to secure a very complete set of pictures of the moon in yellow and ultra-violet light and some forty negatives of Jupiter and Saturn in infra-red, yellow, violet and ultra-violet light. The telescope was used at the eighty foot focus and as the mirrors were silvered, the region of the spectrum utilized for the ultra-violet photography was slightly less refrangible than in the earlier work. Preliminary experiments had been made on the spectrum of sunlight after three reflections from silver and transmission through the bromine cell. Full data regarding these matters will be published shortly in the *Astrophysical Journal.*

Extremely interesting results were obtained in the case of Saturn. The infra-red picture, taken by wave lengths above 7200, showed the ball of the planet almost devoid of surface markings, the merest trace of the faint narrow belts appearing. The photographs made with the yellow screen showed the belts distinctly, giving about the same impression as visual observations. On the plates made with the violet ray-filter (transmission 4000–4500), a very broad dark belt surrounded the planet's equator, occupying the region of the planet which was brightest in yellow light. In addition to this dark equatorial belt a dark polar cap of considerable size appeared in the pictures. So different were the two pictures that, were it not for the ring, it would be difficult to believe that they represented the same object. In ultra-violet light the appearance was much the same, but the dark belt was not quite so wide, the bright region between the polar cap and the belt being distinctly broader.

Photographs made with the four monochromatic filters are reproduced. Two hypotheses suggested themselves in explanation of the dark belt. We may be dealing with a fine mist or dust which forms an extension of the crepe ring down to the ball of the planet. This hypothesis appears to be favored by the circumstance that on the negatives made by ultra-violet light (and to a less degree by violet) the sky between the ball of the planet and the ring is distinctly denser than the region just outside. This would indicate that the region inside of the ring was filled with some material which reflected the short wave-lengths to a slight degree. No trace of this darkening appears on any of the plates made with the yellow screen, even on one that was many times overexposed, which

appears to show that the phenomenon is real. This peculiarity was, however, not detected until the work was finished, and I should prefer to verify it, or have it verified, before setting it down as an established fact. The luminosity is much too feeble to show in the prints. Dr. Hale will have the density measured with the Hartman photometer as soon as some repairs are finished. I do not, however, believe that the dark belt is in reality due to the absorption of a dust ring, for measurements made by Mr. Ellerman showed that the belt extended higher up on the ball of the planet than the line of intersection of the plane of the rings. Moreover it seems highly probable that the belt and the dark polar cap are to be explained in the same way. The second hypothesis assumes the existence in the planet's atmosphere of some substance capable of absorbing violet and ultra-violet light. This material might be a fine mist or dust, or some gas capable of absorbing the more refrangible part of the spectrum. Such a gas would be of a pale yellow color, and sulphur vapor and chlorine naturally occur to us.

I have, however examined the absorption spectrum of both of these gases in quartz bulbs, with the result that the absorption appears to be much stronger in the ultra-violet than in the violet, which is in disagreement with the circumstance that the band appears wider in violet than in ultra-violet light. Until spectrograms are available showing the complete spectra of the different zones of the planet it is useless to speculate as to the nature of the material which causes the absorption. On the infra-red photograph the ball of the planet is much brighter in



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comparison to the brightest part of the ring than on the violet and ultra-violet pictures. This again suggests a mist or dust in the planet's atmosphere which scatters the shorter wave-lengths. My infra-red photographs of landscapes have clearly demonstrated that we can obtain clear photographs through a blue haze by means of the spectrum region above 7200. In these photographs it will be remembered that the blue sky comes out black and the grass and foliage snow white. (See my *Physical Optics*, page 626, second edition.)

Interesting results were obtained as well in the case of Jupiter. In infra-red light the belts were scarcely visible, while the violet and especially the ultra-violet pictures showed dark belts, of which no trace could be seen in pictures made with the yellow screen, or by eye observations of the planet.

In view of the interesting results obtained with these two planets I hope that similar observations will be made of Mars on the occasion of its next near approach to the earth. I made one photograph of the planet in October with ultra-violet light, but the disc was too small to show much of interest.

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